

40-A110 768

WASHINGTON UNIV SEATTLE DEPT OF PSYCHOLOGY  
INDIVIDUAL DIFFERENCES IN DUAL TASK PERFORMANCE. (U)  
JUN 81 M LANSMAN, E HUNT

F/6 5/10

N00014-77-C-0225

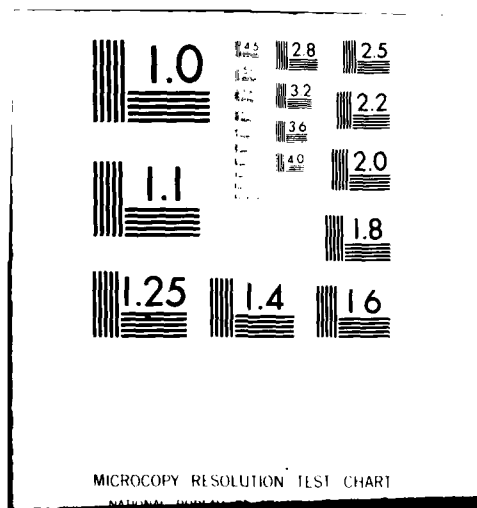
NL

UNCLASSIFIED

For 1  
AE 8/8/81




END  
DATE  
FILMED  
3-82  
DTIC



NO AD

11/30

①

LEVEL

DTIC  
A

AD A110768

Individual Differences  
in  
Dual Task Performance

Marcy Lansman and Earl Hunt  
University of Washington

DTIC  
ELECTE  
JEB 11 1982  
B

APPROVED FOR PUBLIC RELEASE  
DISTRIBUTION STATEMENT

The Ruth H. Bishop Technical Library

Nov 11 1981

Naval Research Laboratory

Final Report  
June 10, 1981

This research was sponsored by:

Personnel and Training Research Programs  
Psychological Sciences Divisions  
Office of Naval Research  
Under Contract No. N00014-77-C-0225  
Contract Authority Identification Number, NR 154-398

Approved for public release; distribution unlimited.

Reproduction in whole or in part is permitted  
for any purpose of the U.S. Government.

THIS FILE COPY

8 2 02 10 024

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER FINAL REPORT	2. GOVT ACCESSION NO. A110 768	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Individual Differences in Dual Task Performance.		5. TYPE OF REPORT & PERIOD COVERED Final Report 4/1/77-3/31/80	
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) Marcy Lansman Earl Hunt		8. CONTRACT OR GRANT NUMBER(s) N00014-77-C-0225	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Psychology University of Washington Seattle, Washington 98195		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N RR 042-06; RR 042-06-01; NR 154-398;	
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (Code 458) Arlington, Virginia 22217		12. REPORT DATE June 10, 1981	
		13. NUMBER OF PAGES 20	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) attention, individual differences, dual tasks, secondary tasks, reaction time.			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The topic of the research was individual differences in dual task performance. It addressed the basic question: Is performance on multi-component tasks predicted by performance on the individual components performed separately? In the first series of experiments, we used a dual task involving memory and verbal processing components to predict a psychometric measure of verbal ability. Single and dual task performance were found to be highly correlated. The two types of measures predicted performance on the criterion verbal ability measure equally well. In a			

second experimental series, we compared ability to detect visual and auditory targets in single-channel, focused attention, and divided attention conditions. Performance in the single channel conditions predicted performance in focused and divided attention conditions almost perfectly. In neither of these two types of experiments did we find evidence for a time-sharing ability. Finally, we used performance on a simple secondary task executed during an easy primary task to predict performance on a more difficult version of the same primary task. In this case, dual task performance provided information not available from the single task counterpart. The "easy-to-hard" prediction technique was found to be a successful method of predicting performance on difficult tasks.

The theoretical basis of this research was provided by a "general resource" theory of attention, in which all mental processes are seen as drawing on the same pool of attentional capacity. During the contract period, a more explicit model of inter-task interference was developed. This model, which we have called the Production Activation Model, will provide the basis for research under the new contract #N-00014-80-C-0631.

Discussion For		
1. Summary	<input checked="" type="checkbox"/>	
2. Objectives	<input type="checkbox"/>	
3. Methods	<input type="checkbox"/>	
4. Results	<input type="checkbox"/>	
5. Conclusions	<input type="checkbox"/>	
Distribution/		
Availability Codes		
Avail and/or		
Special		
A		

This report summarizes the research carried out under contract #N-00014-77-C-0225. All of the studies reported here have been described in previous technical reports or publications. The purpose of this document is to summarize the results and to provide a reference for specific sources.

#### BACKGROUND

During the 1970's, a number of psychologists began to relate the ability concepts derived from psychometric testing to the process concepts developed by cognitive psychologists. In this laboratory, we adapted a number of experimental tasks to yield individual measures of the speed and accuracy of various cognitive processes (Hunt, 1978a; Hunt, Frost, & Lunneborg, 1973; Hunt, Lunneborg, & Lewis, 1975). These measures were correlated with standardized measures of academic ability. Modest correlations were found between a number of process and ability measures. Most notably, a relationship was found between verbal ability and speed of access to information in long-term memory. This finding has been replicated by a number of other investigators (Goldberg, Schwartz, & Stewart, 1977; Jackson & McClelland, 1979; Jackson, 1980; Keating & Bobbitt, 1978). Our work on the relationship between cognitive processes and verbal ability is summarized in Technical report #1 (Hunt, 1978b).

The major thrust of the effort to relate cognitive and psychometric measures has been to analyze complex psychometric abilities in terms of simpler and better understood cognitive

processes. For example, the typical psychometric measures of "verbal ability" combines scores on vocabulary, reading comprehension, and several other subtests. We wanted to discover the extent to which speed and accuracy of various simple mechanistic cognitive processes was related to performance on ability measures. Such an approach complements attempts to analyze complex task performance by breaking the tasks themselves into discrete stages (Sternberg, 1980).

ONR Contract #N-00014-77-C-0225 extended the idea that individual variation in complex cognitive processes could be explained in terms of variability in simple components of those processes. Previously we had asked whether the speed and accuracy of simple processes would predict ability scores. In this research, we asked whether the effort required by the simple tasks would predict performance on the more complex tasks. In many cases, complex intellectual tasks require that a person do two or more things at once. For example, mental arithmetic requires a person to hold partial results in memory while computing later results. If the person's total mental capacity is required to hold partial results in memory, then little capacity will be available to make further calculations. In this case, neither speed nor accuracy of the separate memory and computations processes would be sufficient to predict performance on the complex mental computation task. Some measure of the effort required by the component tasks would also be required.

The idea of 'mental effort' is closely related to the notion

that it is difficult to attend to several things at once. A conceptually simple model of attention as the expenditure of mental capacity was put forward by Moray (1967), and later by Kahneman (1973), and extended by others (Navon & Gopher, 1979; Norman & Bobrow, 1975). According to Kahneman, all mental processes draw from a single pool of mental resources, called 'attentional capacity.' Two simultaneously performed mental tasks interfere with one another if their combined attentional demands exceed the person's total attentional capacity. We will refer to this as the 'general resource model' of attention. In our research, we have applied the general resource model to the field of individual differences. Suppose that people vary in their characteristic level of attentional capacity or in the efficiency with which they perform specific tasks. To what extent will this determine their relative performance on various cognitive tasks?

The idea that attentional factors might be a source of individual differences led us to propose two lines of research. In the first, we asked whether performance on the two component tasks performed separately would predict performance on the same two tasks performed simultaneously, and further, whether performance in the dual-task situation would be more highly related to complex cognitive ability measures than performance on the components. In the second line of research, we tested what we have called the 'easy-to-hard prediction' hypothesis. According to this hypothesis, performance on a secondary task executed during the easy version of a complex primary task should predict



performance on a harder version of the same primary task.

#### SINGLE AND DUAL TASK MEASURES AS PREDICTORS OF VERBAL ABILITY

Two of our first studies of individual differences in attentional factors developed from an earlier interest in predicting verbal ability. We reasoned that many complex verbal tasks require that people hold verbal information in memory while encoding and manipulating new information. For example, the noun phrase of a sentence must be held in memory while the verb is encoded and processed. Each paragraph of an essay must be interpreted in light of the information retained from earlier paragraphs. Thus it seemed that a) both linguistic processing the verbal short-term memory should be important in predicting verbal ability; and b) the ability to carry out both functions simultaneously might be more important than the ability to carry them out in isolation.

We tested these hypotheses in two experiments. They are described in Technical Report #2 (Lansman, 1978). In these experiments, subjects were asked to perform two tasks: a rote recall task and a sentence verification task. In the dual task conditions, a list of items was presented, and while these items were being retained in memory, the subject was asked to respond 'true' or 'false' to a series of sentence verification items (e.g., "Plus is above star. <sup>+</sup> "). Finally, the memory items were recalled. In the single task conditions, the recall and sentence

verification tasks were performed separately. We reasoned that if subjects differed either in their total attentional capacity or in the efficiency with which they performed either recall or sentence verification tasks, then these differences would be reflected in dual but not single task performance. In that case, dual and single task measures would be imperfectly correlated, and dual task measures might be more strongly related to complex measures of verbal ability.

In fact, single and dual task measures were quite highly correlated, and the patterns of correlations between the two types of tasks and the criterion ability measures were almost identical. The experiments provided no evidence for an attention-related 'time-sharing' factor. Single and dual task measures were equally accurate in predicting verbal ability.

These studies indicated that a dual task combining rote memory and linguistic processing does not improve prediction of verbal ability over that provided by single task measures. There are several studies in the literature in which subjects were asked to perform a number of tasks both separately and in combination (e.g., Jennings & Chiles, 1977; Sverko, 1977). These studies were motivated by the hypothesis that there is a general ability to do two things at once and that this ability should manifest itself in dual task performance. In fact, no general time-sharing factor emerged in the analysis of the correlations among dual and single task measures. Thus, our results were consistent with a number of other studies in suggesting that there is no general time-sharing

factor, and that in many cases dual-task performance is quite well predicted by performance of component tasks.

A recent study by Daneman and Carpenter (1980) calls this conclusion into question. In their study, memory and verbal processing tasks were combined in a slightly different way: Subjects were asked to remember the final word in each of a series of sentences that they were reading for comprehension. Thus, in their dual task, memory and verbal processing tasks were integrated. Daneman and Carpenter found a very high correlation between accuracy of recall and reading ability. In contrast, we and others (Lansman, 1978; Palmer, MacLeod, Hunt, & Davidson, Note 1; Perfetti & Lesgold, 1977) have found virtually no relationship between rote memory and verbal ability in the college population. If the Daneman and Carpenter finding proves replicable, it suggests that verbal ability, or at least reading ability, is related to the ability to combine memory and verbal processing, but that the relationship is only evident when the memory and processing components are closely integrated. As the Daneman and Carpenter study used a very small sample of highly selected people, replication of their results is clearly in order.

#### FOCUSED AND DIVIDED ATTENTION

In the research discussed so far, 'time-sharing' has been used to refer to a subject's ability to divide attention between two competing tasks. Time-sharing ability may also refer to the

ability to divide attention between two competing channels of information. We investigated this ability using dichotic listening and visual search tasks. If there is an ability to divide attention between two sources of information, then we would expect performance in a single channel condition to be an imperfect predictor of performance in a divided attention conditions. We might also expect the ability to divide attention between the two ears to be related to the ability to divide attention between two visual locations. Our research on the ability to divide attention between two channels of information described in Technical Report #9 (Poltrock, Lansman, & Hunt, 1980).

In a large study of individual differences in the ability to divide and focus attention, we asked subjects to perform both dichotic listening and visual search tasks. In both cases, they were asked to press a key when they heard or saw one of a set of target letters. For each modality, there were three conditions: single channel (letters were presented to a single ear or at a single location), focused attention (letters were presented at two locations, but all targets occurred in a single location), and divided attention (targets could occur at either of two locations). The dependent measures were reaction time and accuracy in detecting target letters. Although reaction times were considerably slower and responses less accurate in focused and divided than in the single channel condition, performance in the three conditions was very highly correlated within modality.

In other words, performance in the single channel condition predicted performance in the other two conditions almost perfectly. The LISREL program for analysis of covariance structures was used to fit several models to the data. A model containing one factor for reaction times to auditory stimuli and a second factor for reaction times to visual stimuli provided a very good fit. The visual and auditory factors were correlated with each other ( $r = .61$ ). No separate factors corresponding to the ability to divide or focus attention were required to explain the data.

In summary, the conclusions drawn from the study of divided and focused attention were similar to the conclusions drawn from the study of time-sharing between competing tasks: There was no evidence that the ability to divide attention between two tasks was an important source of individual differences in performance. In both cases, performance in the single channel or single task condition predicted performance in the divided attention or dual task situation almost perfectly.

In developing the dichotic listening task, it was possible to study an issue which, though not directly concerned with individual differences, has some interesting implications for attentional theory. Previous studies comparing single channel and divided attention conditions in the auditory modality had commonly used what Schneider and Shiffrin (1977) have called 'consistent mapping conditions,' which minimize demands on attentional capacity. Throughout these experiments, one set of stimuli were

designated as targets and another set as distractors. It had been found that accuracy is about equal in single-channel and divided attention conditions as long as two stimuli do not occur simultaneously on the two channels. (See, for example, Ostry, Moray, & Marks, 1976.) We wondered whether this finding was related to the reduced attentional demands of the consistent mapping condition. Accordingly, we had subjects perform the dichotic listening task under both consistent and varied mapping conditions. The consistent-varied distinction proved to be as important in auditory target detection as Schneider and Shiffrin had shown it to be in visual search. Reaction time was much faster and accuracy higher under consistent mapping conditions. Furthermore, there was a much smaller memory set size effect under consistent mapping conditions, and this effect decreased over practice. These results are reported in more detail in Technical Report #9 (Pollock, Lansman, & Hunt, 1980), and also in a report that is in publication (Pollock, Lansman, & Hunt, in press).

#### EASY-TO-HARD PREDICTION

A major part of our research on this contract has concerned what we have called 'easy-to-hard prediction.' Like the research described above, this technique involves examination of individual differences in dual-task performance. However, the rationale is somewhat different. When two tasks are performed simultaneously, they compete for attentional capacity. If one of the tasks is designated as 'primary' and the other as 'secondary,' then the

primary task should receive top priority in the allocation of resources, and the secondary task should receive what is left. Secondary task performance should therefore reflect spare capacity available during performance of the primary task. We reasoned that spare capacity available during performance of an easy primary task should be available for performance of a harder version of the same primary task. Thus performance on a secondary task during an easy primary task should predict performance on a harder version of the same primary task -- the 'easy-to-hard prediction.'

The rationale behind the easy-to-hard prediction technique is derived more formally in Technical Report #8 (Hunt & Lansman, 1980). A revised version of this report is also to be published in a book edited by R. Sternberg (Hunt & Lansman, in press). In that paper, we assumed that performance on any task is a function of two individual parameters: a structural parameter specific to that particular task, and a resource parameter reflecting the amount of general attentional resources available to the task. We showed that performance of the secondary task during the easy primary would provide information concerning the resource parameter that was unavailable from single task performance. Since the derivation was done in terms of classic information theory, it made no assumptions concerning the form of the relationship between performance and resources available.

The easy-to-hard prediction technique has been tested in several experiments, which are described in Technical Reports #2

(Lansman, 1978), #4 (Hunt, Lansman, & Wright, 1979), and #7 (Lansman & Hunt, 1980). In several of these experiments, the primary task was a continuous paired associate learning task in which subjects were asked to keep track of two to seven letter-number pairs, while the secondary task required subjects to respond as quickly as possible to a simple probe stimulus. Reaction time to probes that occurred during an easy version of the paired associate primary task predicted performance on a harder version of the paired associate task. In another experiment the primary task was a spatial memory task in which subjects were asked to judge whether a spatial pattern was identical to a standard pattern and the secondary task again involved response to a probe stimulus. In this experiment, reaction time to the secondary probes did not significantly improve prediction of performance on the hard version of the primary task. The differences between the paired associate and the spatial memory tasks seemed to be that resource availability was the limiting factor in performance of the paired associate but not the spatial memory task.

The easy-to-hard technique was also used in an experiment involving a slightly different paradigm, described more fully in Technical Reports #4 (Hunt, Lansman, & Wright, 1979) and #8 (Hunt, 1979). (Report #8 has also been published in the British Journal of Psychology (Hunt, 1981)). In this case, the primary task was the Raven Progressive Matrix Test and the secondary task required subjects to exert a constant pressure on a lever. On the Raven



Test, each item is more difficult than the previous item. Performance on the secondary task during any given Raven item was found to provide information concerning which subjects were about to make a mistake on the succeeding item. Interpreted within the general resource theory, the results showed that those subjects whose total capacity was required by one problem (producing poor performance on the secondary task) were likely to fail to solve the succeeding, more difficult problem.

In earlier sections of this paper, we reported several experiments in which performance in dual-task conditions was very accurately predicted by performance in single task conditions. Here we are arguing that performance of a simple secondary task does indeed provide information unavailable from performance of the single-task counterpart. How can this contradiction be resolved? The issue is discussed in Technical Report #8 (Hunt & Lansman, 1980). Performance on most complex tasks reflects both structural parameters and resource limitations, whether the tasks are performed in single or dual-task conditions. If this is the case, then we would expect single and dual task performance to be highly correlated since they both reflect the same underlying parameters. However, some simple tasks, such as response to a single probe stimulus, are 'data-limited' under single task conditions. That is, performance of these tasks would not be improved if additional resources were allocated to them. However, under dual-task conditions, these same tasks become resource-limited! Performance is inversely related to the amount

of resources drawn off by the primary task. In this case, performance in the single-task conditions reflects only structural parameters specific to the task, while secondary task performance reflects both structural and resource parameters. The result is that single and dual task performance are not highly correlated. Dual task performance provides information concerning resources available during the primary task. This information can be used to predict performance on a harder version of the same primary task.

#### A THEORY OF ATTENTION

The theoretical basis of the easy-to-hard technique was a simple theory of attention, in which all mental processes were seen as drawing upon a general attentional resource. The strength of such a theory lies in its simplicity and ability to summarize a vast amount of data on dual-task interference. Its weakness is the fact that 'attentional capacity' is a strictly hypothetical construct, and is not tied to any other physiological or even theoretical entity. Implicit in the general resource theory is an analogy between attentional resources and physical energy sources such as electricity or water power. But while energy resources are well-defined within theories of physics, attentional resources are defined only by analogy.

During the contract period, we have developed a more explicit model of attention, called the Production Activation Model. The theory is described in detail in a paper by Hunt (in press). It

is closely related to models of thinking developed in the fields of cognitive science and artificial intelligence. However, the Production Activation Model goes beyond these theories in that it deals with the problem of how the organism handles competing stimuli. Within the model, mental activity consists of the execution of a series of productions. These productions are stored in long-term memory. It is the function of a decision mechanism to determine the order in which the productions will be executed. At any given moment, the external world and the contents of short-term memory form a stimulus configuration. This configuration activates a number of productions. Which production will actually be executed depends upon two things: a) the match of the stimulus configuration to the pattern specified by the production, and b) the baseline activation level of each of the productions. The baseline activation level of a production is strongly influenced by the productions that have preceded it. The execution of one production biases the system toward the execution of certain other productions in such a way that a well-practiced task consists of a chain of productions that is usually executed as an unbroken sequence. Within this model, structural interference results from competition for one of the effectors involved in the execution of productions. Central interference results from competition for access to the decision mechanism.

Within the Production Activation Model, the decision mechanism fills the role that 'general attentional capacity' filled in the General Resource Model. Both are strictly

theoretical concepts. The difference is that the function of the decision mechanism is more fully specified within the Production Activation Model. The model thus allows us to formulate more specific questions concerning dual task interference. These questions concern the role of practice, task priority, expectancy, and several other variables. Our new contract, #N-00014-80-C-0631, was formulated within the framework provided by the Production Activation Model. Under this contract, we have proposed two main lines of research. We will a) develop a computer simulation of the Production Activation Model, and b) empirically investigate some the the questions raised by the model. The empirical investigation will provide data against which to test the computer simulation.

Reference Note

Palmer, J.C., MacLeod, C.M., Hunt, E., & Davidson, J.E. Is visual information processing related to reading? Unpublished paper.

References

Daneman, M., & Carpenter, P.A. Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 450-466.

Goldberg, R.A., Schwartz, S., & Stewart, M. Individual differences in cognitive processes. *Journal of Educational Psychology*, 1977, 69, 9-14.

Hunt, E. Mechanics of verbal ability. *Psychological Review*, 1978a, 85, 109-130.

Hunt, E. The foundations of verbal comprehension. Technical Report #1, University of Washington, 1978b.

Hunt, E. Intelligence as an information processing concept. Technical Report #5, University of Washington, 1979.

Hunt, E. Intelligence as an information processing concept. *British Journal of Psychology*, 1980, 71, 449-474.

Hunt, E. The design of a robot mind: A theoretical approach to issues in intelligence. In M. Friedman, J.P. Das, & N. O'Connor (Eds.), *Intelligence and Learning*. New York: Plenum, in press.

Hunt, E., Frost, N., & Lunneborg, C. Individual differences in cognition : A new approach to intelligence. In G. Bower (Ed.), *The Psychology of Learning and Motivation* (Vol. 7). New York: Academic Press, 1973.

Hunt, E., & Lansman, M. Individual differences in attention. Technical Report #8, University of Washington, 1980.

Hunt, E., & Lansman, M. Individual differences in attention. In R. Sternberg (Ed.), *Advances in the Psychology of Intelligence* (Vol. 1). Hillsdale, N.J.: Erlbaum, in press.

Hunt, E., Lansman, M., & Wright, J. Some remarks on doing two things at once. Technical Report #4, University of Washington, 1979.

Hunt, E. Lunneborg, C., & Lewis, J. What does it mean to be high verbal? *Cognitive Psychology*, 1975, 7, 194-227.

Jackson, M.O. Further evidence for a relationship between memory access and reading ability. *Journal of Verbal Learning and Verbal*

Behavior, 1980, 19, 683-694.

Jackson, M.D. & McClelland, J.L. Processing determinants of reading speed. Journal of Experimental Psychology: General, 1979, 108, 151-181.

Jennings, A.E. & Chiles, W.G. An investigation of time-sharing ability as a factor in operator performance. Human Factors, 1977, 19, 535-547.

Kahneman, D. Attention and Effort. Englewood Cliffs, N.J.: Prentice-Hall, 1973.

Keating, D.P., & Bobbitt, B.L. Individual and developmental differences in cognitive-processing components of mental ability. Child Development, 1978, 49, 155-167.

Lansman, M. An attentional approach to individual differences in immediate memory. Technical Report #2, University of Washington, 1978.

Lansman, M. & Hunt, E. Individual differences in dual task performance. Technical Report # 7, University of Washington, 1980.

Moray, N. Where is capacity limited? Acta Psychologica, 1967,

27, 84-92.

Navon, D., & Gopher, D. On the economy of the human processing system. *Psychological Review*, 1979, 86, 214-255.

Norman, D.A., & Bobrow, D.B. On data-limited and resource-limited processes. *Cognitive Psychology*, 1975, 7, 44-64.

Ostry, D., Moray, N., & Marks, G. Attention, practice, and semantic targets. *Journal of Experimental Psychology: Human Perception and Performance*, 1976, 2, 326-336.

Perfetti, C.A., & Lesgold, A.M. Discourse comprehension and sources of individual differences. In M.A. Just & P.A. Carpenter (Eds.), *Cognitive Processes in Comprehension*. Hillsdale, N.J.: Erlbaum, 1977.

Poltrock, S.E., Lansman, M., & Hunt, E. Automatic and controlled processes in auditory detection. Technical Report #9, University of Washington, 1980.

Poltrock, S.E., Lansman, M., & Hunt, E. Automatic and controlled processes in auditory target detection. *Journal of Experimental Psychology: Human Perception and Performance*, in press.

Schneider, W., & Shiffrin, R.M. Controlled and automatic human



information processing: I. Detection, search, and attention.  
Psychological Review, 1977, 84, 1-66.

Sternberg, R.J. Sketch of a componential subtheory of human  
intelligence. Behavioral and brain sciences, 1980, 3, 573-614.

Sverko, B. Individual differences in time-sharing performance.  
Acta Instituti Psychologici, 1977, 79, 17-30.

Navy

- 1 Meryl S. Baker  
NPRDC  
Code P309  
San Diego, CA 92152
- 1 Dr. Robert Breaux  
Code N-711  
NAVTRAEQUIPCEN  
Orlando, FL 32813
- 1 Chief of Naval Education and Training  
Liason Office  
Air Force Human Resource Laboratory  
Flying Training Division  
WILLIAMS AFB, AZ 85224
- 1 Dr. Richard Elster  
Department of Administrative Sciences  
Naval Postgraduate School  
Monterey, CA 93940
- 1 DR. PAT FEDERICO  
NAVY PERSONNEL R&D CENTER  
SAN DIEGO, CA 92152
- 1 Mr. Paul Foley  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. John Ford  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. Henry M. Halff  
Department of Psychology, C-009  
University of California at San Diego  
La Jolla, CA 92093
- 1 LT Steven D. Harris, MSC, USN  
Code 6021  
Naval Air Development Center  
Warminster, Pennsylvania 18974
- 1 Dr. Patrick R. Harrison  
Psychology Course Director  
LEADERSHIP & LAW DEPT. (7b)  
DIV. OF PROFESSIONAL DEVELOPMENT  
U.S. NAVAL ACADEMY  
ANNAPOLIS, MD 21402

Navy

- 1 Dr. Jim Hollan  
Code 304  
Navy Personnel R & D Center  
San Diego, CA 92152
- 1 CDR Charles W. Hutchins  
Naval Air Systems Command Hq  
AIR-340F  
Navy Department  
Washington, DC 20361
- 1 CDR Robert S. Kennedy  
Head, Human Performance Sciences  
Naval Aerospace Medical Research Lab  
Box 29407  
New Orleans, LA 70189
- 1 Dr. Norman J. Kerr  
Chief of Naval Technical Training  
Naval Air Station Memphis (75)  
Millington, TN 38054
- 1 Dr. William L. Maloy  
Principal Civilian Advisor for  
Education and Training  
Naval Training Command, Code 00A  
Pensacola, FL 32508
- 1 Dr. Kneale Marshall  
Scientific Advisor to DCNO(MPT)  
OP01T  
Washington DC 20370
- 1 CAPT Richard L. Martin, USN  
Prospective Commanding Officer  
USS Carl Vinson (CVN-70)  
Newport News Shipbuilding and Drydock Co  
Newport News, VA 23607
- 1 Dr. James McBride  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. George Moeller  
Head, Human Factors Dept.  
Naval Submarine Medical Research Lab  
Groton, CN 06340

Navy

- 1 Dr William Montague  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Ted M. I. Yellen  
Technical Information Office, Code 201  
NAVY PERSONNEL R&D CENTER  
SAN DIEGO, CA 92152
- 1 Library, Code P201L  
Navy Personnel R&D Center  
San Diego, CA 92152
- 6 Commanding Officer  
Naval Research Laboratory  
Code 2627  
Washington, DC 20390
- 1 Psychologist  
ONR Branch Office  
Bldg 114, Section D  
666 Summer Street  
Boston, MA 02210
- 1 Psychologist  
ONR Branch Office  
536 S. Clark Street  
Chicago, IL 60605
- 1 Office of Naval Research  
Code 437  
800 N. Quincy Street  
Arlington, VA 22217
- 1 Office of Naval Research  
Code 441  
800 N. Quincy Street  
Arlington, VA 22217
- 5 Personnel & Training Research Programs  
(Code 458)  
Office of Naval Research  
Arlington, VA 22217
- 1 Psychologist  
ONR Branch Office  
1030 East Green Street  
Pasadena, CA 91101

Navy

- 1 Office of the Chief of Naval Operations  
Research Development & Studies Branch  
(OP-115)  
Washington, DC 20350
- 1 Dr. Donald F. Parker  
Graduate School of Business Administration  
University of Michigan  
Ann Arbor, MI 48109
- 1 LT Frank C. Petho, MSC, USN (Ph.D)  
Selection and Training Research Division  
Human Performance Sciences Dept.  
Naval Aerospace Medical Research Laboratory  
Pensacola, FL 32508
- 1 Roger W. Remington, Ph.D  
Code L52  
NAMRL  
Pensacola, FL 32508
- 1 Dr. Bernard Rimland (03B)  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 Dr. Worth Scanland, Director  
Research, Development, Test & Evaluation  
N-5  
Naval Education and Training Command  
NAS, Pensacola, FL 32508
- 1 Dr. Sam Schiflett, SY 721  
Systems Engineering Test Directorate  
U.S. Naval Air Test Center  
Patuxent River, MD 20670
- 1 Dr. Robert G. Smith  
Office of Chief of Naval Operations  
OP-987H  
Washington, DC 20350
- 1 Dr. Alfred F. Snodde  
Training Analysis & Evaluation Group  
(TAEG)  
Dept. of the Navy  
Orlando, FL 32813

Navy

- 1 W. Gary Thomson  
Naval Ocean Systems Center  
Code 7132  
San Diego, CA 92152
- 1 Roger Weissinger-Baylon  
Department of Administrative Sciences  
Naval Postgraduate School  
Monterey, CA 93940
- 1 Dr. Ronald Weitzman  
Code 54 WZ  
Department of Administrative Sciences  
U. S. Naval Postgraduate School  
Monterey, CA 93940
- 1 Dr. Robert Wisher  
Code 309  
Navy Personnel R&D Center  
San Diego, CA 92152
- 1 DR. MARTIN F. WISKOFF  
NAVY PERSONNEL R & D CENTER  
SAN DIEGO, CA 92152
- 1 Mr John H. Wolfe  
Code P310  
U. S. Navy Personnel Research and  
Development Center  
San Diego, CA 92152

Army

- 1 Technical Director  
U. S. Army Research Institute for the  
Behavioral and Social Sciences  
5001 Eisenhower Avenue  
Alexandria, VA 22333
- 1 Dr. Dexter Fletcher  
U.S. Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, VA 22333
- 1 Dr. Michael Kaplan  
U.S. ARMY RESEARCH INSTITUTE  
5001 EISENHOWER AVENUE  
ALEXANDRIA, VA 22333
- 1 Dr. Milton S. Katz  
Training Technical Area  
U.S. Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, VA 22333
- 1 Dr. Harold F. O'Neil, Jr.  
Attn: PERI-OK  
Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, VA 22333
- 1 Dr. Robert Sasmor  
U. S. Army Research Institute for the  
Behavioral and Social Sciences  
5001 Eisenhower Avenue  
Alexandria, VA 22333
- 1 Dr. Joseph Ward  
U.S. Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, VA 22333

## Air Force

Air University Library  
AUL/LSE 76/443  
Maxwell AFB, AL 36112

Dr. Earl A. Alluisi  
HQ, AFHRL (AFSC)  
Brooks AFB, TX 78235

Dr. Genevieve Haddad  
Program Manager  
Life Sciences Directorate  
AFOSR  
Bolling AFB, DC 20332

Dr. Ronald G. Hughes  
AFHRL/OTR  
Williams AFB, AZ 85224

Dr. Malcolm Ree  
AFHRL/MP  
Brooks AFB, TX 78235

Dr. Marty Rockway  
Technical Director  
AFHRL(OT)  
Williams AFB, AZ 58224

3700 TCHTW/TTGH Stop 32  
Sheppard AFB, TX 76311

## Marines

1 H. William Greenup  
Education Advisor (E031)  
Education Center, MCDEC  
Quantico, VA 22134

1 Headquarters, U. S. Marine Corps  
Code MPI-20  
Washington, DC 20380

1 Special Assistant for Marine  
Corps Matters  
Code 100M  
Office of Naval Research  
800 N. Quincy St.  
Arlington, VA 22217

1 DR. A.L. SLAFKOSKY  
SCIENTIFIC ADVISOR (CODE RD-1)  
HQ, U.S. MARINE CORPS  
WASHINGTON, DC 20380

CoastGuard

- 1 Chief, Psychological Research Branch  
U. S. Coast Guard (G-P-1/2/TP42)  
Washington, DC 20593
- 1 Mr. Thomas A. Warm  
U. S. Coast Guard Institute  
P. O. Substation 18  
Oklahoma City, OK 73169

Other DoD

- 12 Defense Technical Information Center  
Cameron Station, Bldg 5  
Alexandria, VA 22314  
Attn: TC
- 1 Military Assistant for Training and  
Personnel Technology  
Office of the Under Secretary of Defense  
for Research & Engineering  
Room 3D129, The Pentagon  
Washington, DC 20301
- 1 DARPA  
1400 Wilson Blvd.  
Arlington, VA 22209

Civil Govt

- 1 Dr. Susan Chipman  
Learning and Development  
National Institute of Education  
1200 19th Street NW  
Washington, DC 20208
- William J. McLaurin  
66610 Howie Court  
Camp Springs, MD 20031
- Dr. Andrew R. Molnar  
Science Education Dev.  
and Research  
National Science Foundation  
Washington, DC 20550
- Dr. Joseph Psotka  
National Institute of Education  
1200 19th St. NW  
Washington, DC 20208
- Dr. H. Wallace Sinaiko  
Program Director  
Manpower Research and Advisory Services  
Smithsonian Institution  
801 North Pitt Street  
Alexandria, VA 22314
- Dr. Frank Withrow  
U. S. Office of Education  
400 Maryland Ave. SW  
Washington, DC 20202
- Dr. Joseph L. Young, Director  
Memory & Cognitive Processes  
National Science Foundation  
Washington, DC 20550

Non Govt

- 1 Dr. John R. Anderson  
Department of Psychology  
Carnegie Mellon University  
Pittsburgh, PA 15213
- 1 Dr. John Annett  
Department of Psychology  
University of Warwick  
Coventry CV4 7AL  
ENGLAND
- 1 DR. MICHAEL ATWOOD  
SCIENCE APPLICATIONS INSTITUTE  
40 DENVER TECH. CENTER WEST  
7935 E. PRENTICE AVENUE  
ENGLEWOOD, CO 80110
- 1 1 psychological research unit  
Dept. of Defense (Army Office)  
Campbell Park Offices  
Canberra ACT 2600, Australia
- 1 Dr. Alan Baddeley  
Medical Research Council  
Applied Psychology Unit  
15 Chaucer Road  
Cambridge CB2 2EF  
ENGLAND
- 1 Dr. Patricia Baggett  
Department of Psychology  
University of Denver  
University Park  
Denver, CO 80208
- 1 Dr. Jackson Beatty  
Department of Psychology  
University of California  
Los Angeles, CA 90024
- 1 Dr. Isaac Bejar  
Educational Testing Service  
Princeton, NJ 08450
- 1 CDR Robert J. Biersner  
Program Manager  
Human Performance  
Navy Medical R&D Command  
Bethesda, MD 20014

Non Govt

Dr. Ina Bilodeau  
Department of Psychology]  
Tulane University  
New Orleans, LA 70118

Liaison Scientists  
Office of Naval Research,  
Branch Office, London  
Box 39 FPO New York 09510

Dr. Lyle Bourne  
Department of Psychology  
University of Colorado  
Boulder, CO 80309

Col Ray Bowles  
800 N. Quincy St.  
Room 804  
Arlington, VA 22217

Dr. Robert Brennan  
American College Testing Programs  
P. O. Box 168  
Iowa City, IA 52240

Dr. Bruce Buchanan  
Department of Computer Science  
Stanford University  
Stanford, CA 94305

DR. C. VICTOR BUNDERSON  
WICAT INC.  
UNIVERSITY PLAZA, SUITE 10  
1160 SO. STATE ST.  
OREM, UT 84057

Dr. Pat Carpenter  
Department of Psychology  
Carnegie-Mellon University  
Pittsburgh, PA 15213

Dr. John B. Carroll  
Psychometric Lab  
Univ. of No. Carolina  
Davie Hall 013A  
Chapel Hill, NC 27514

Non Govt

1 Charles Myers Library  
Livingstone House  
Livingstone Road  
Stratford  
London E15 2LJ  
ENGLAND

1 Dr. William Chase  
Department of Psychology  
Carnegie Mellon University  
Pittsburgh, PA 15213

1 Dr. Kenneth E. Clark  
College of Arts & Sciences  
University of Rochester  
River Campus Station  
Rochester, NY 14627

1 Dr. Norman Cliff  
Dept. of Psychology  
Univ. of So. California  
University Park  
Los Angeles, CA 90007

1 Dr. Lynn A. Cooper  
LRDC  
University of Pittsburgh  
3939 O'Hara Street  
Pittsburgh, PA 15213

1 Dr. Meredith P. Crawford  
American Psychological Association  
1200 17th Street, N.W.  
Washington, DC 20036

1 Dr. Kenneth B. Cross  
Anacapa Sciences, Inc.  
P.O. Drawer Q  
Santa Barbara, CA 93102

1 Dr. Ronna Dillon  
Department of Guidance and Educational P  
Southern Illinois University  
Carbondale, IL 62901

1 Dr. Emmanuel Donchin  
Department of Psychology  
University of Illinois  
Champaign, IL 61820



Non Govt

Dr. Hubert Dreyfus  
Department of Philosophy  
University of California  
Berkeley, CA 94720

Dr. William Dunlap  
Department of Psychology  
Tulane University  
New Orleans, LA 70118

LCOL J. C. Eggenberger  
DIRECTORATE OF PERSONNEL APPLIED RESEARCH 1  
NATIONAL DEFENCE HQ  
101 COLONEL BY DRIVE  
OTTAWA, CANADA K1A 0K2

ERIC Facility-Acquisitions  
4833 Rugby Avenue  
Bethesda, MD 20014

Dr. Richard L. Ferguson  
The American College Testing Program  
P.O. Box 168  
Iowa City, IA 52240

Dr. Edwin A. Fleishman  
Advanced Research Resources Organ.  
Suite 900  
4330 East West Highway  
Washington, DC 20014

Dr. John R. Frederiksen  
Bolt Beranek & Newman  
50 Moulton Street  
Cambridge, MA 02138

Dr. Alinda Friedman  
Department of Psychology  
University of Alberta  
Edmonton, Alberta  
CANADA T6G 2E9

Dr. R. Edward Geiselman  
Department of Psychology  
University of California  
Los Angeles, CA 90024

Non Govt

1 DR. ROBERT GLASER  
LRDC  
UNIVERSITY OF PITTSBURGH  
3939 O'HARA STREET  
PITTSBURGH, PA 15213

1 Dr. Marvin D. Glock  
217 Stone Hall  
Cornell University  
Ithaca, NY 14853

Dr. Daniel Gopher  
Industrial & Management Engineering  
Technion-Israel Institute of Technology  
Haifa  
ISRAEL

1 DR. JAMES G. GREENO  
LRDC  
UNIVERSITY OF PITTSBURGH  
3939 O'HARA STREET  
PITTSBURGH, PA 15213

1 Dr. Harold Hawkins  
Department of Psychology  
University of Oregon  
Eugene OR 97403

1 Dr. James R. Hoffman  
Department of Psychology  
University of Delaware  
Newark, DE 19711

1 Glenda Greenwald, Ed.  
"Human Intelligence Newsletter"  
P. O. Box 1163  
Birmingham, MI 48012

1 Dr. Lloyd Humphreys  
Department of Psychology  
University of Illinois  
Champaign, IL 61820

1 Library  
HumRRO/Western Division  
27857 Berwick Drive  
Carmel, CA 93921

Non Govt

Dr. Steven W. Keele  
Dept. of Psychology  
University of Oregon  
Eugene, OR 97403

Dr. David Kieras  
Department of Psychology  
University of Arizona  
Tuscon, AZ 85721

Dr. Kenneth A. Klivington  
Program Officer  
Alfred P. Sloan Foundation  
630 Fifth Avenue  
New York, NY 10111

Dr. Stephen Kosslyn  
Harvard University  
Department of Psychology  
33 Kirkland Street  
Cambridge, MA 02138

Mr. Marlin Kroger  
1117 Via Goleta  
Palos Verdes Estates, CA 90274

Dr. Jill Larkin  
Department of Psychology  
Carnegie Mellon University  
Pittsburgh, PA 15213

Dr. Alan Lesgold  
Learning R&D Center  
University of Pittsburgh  
Pittsburgh, PA 15260

Dr. Charles Lewis  
Faculteit Sociale Wetenschappen  
Rijksuniversiteit Groningen  
Oude Boteringestraat 23  
9712GC Groningen  
Netherlands

Dr. James Lumsden  
Department of Psychology  
University of Western Australia  
Nedlands W.A. 6009  
AUSTRALIA

Non Govt

1 Mr. Merl Malehorn  
Dept. of Navy  
Chief of Naval Operations  
OP-113  
Washington, DC 20350

1 Dr. Erik McWilliams  
Science Education Dev. and Research  
National Science Foundation  
Washington, DC 20550

1 Dr. Mark Miller  
TI Computer Science Lab  
C/O 2824 Winterplace Circle  
Plano, TX 75075

1 Dr. Allen Munro  
Behavioral Technology Laboratories  
1845 Elena Ave., Fourth Floor  
Redondo Beach, CA 90277

1 Dr. Donald A Norman  
Dept. of Psychology C-009  
Univ. of California, San Diego  
La Jolla, CA 92093

1 Dr. Melvin R. Novick  
356 Lindquist Center for Measurement  
University of Iowa  
Iowa City, IA 52242

1 Dr. Jesse Orlansky  
Institute for Defense Analyses  
400 Army Navy Drive  
Arlington, VA 22202

1 Dr. Seymour A. Papert  
Massachusetts Institute of Technology  
Artificial Intelligence Lab  
545 Technology Square  
Cambridge, MA 02139

1 Dr. James A. Paulson  
Portland State University  
P.O. Box 751  
Portland, OR 97207

## Non Govt

- 1 MR. LUIGI PETRULLO  
2431 N. EDGEWOOD STREET  
ARLINGTON, VA 22207
- 1 Dr. Martha Polson  
Department of Psychology  
Campus Box 346  
University of Colorado  
Boulder, CO 80309
- 1 DR. PETER POLSON  
DEPT. OF PSYCHOLOGY  
UNIVERSITY OF COLORADO  
BOULDER, CO 80309
- 1 Dr. Steven E. Poltrock  
Department of Psychology  
University of Denver  
Denver, CO 80208
- 1 Dr. Mike Posner  
Department of Psychology  
University of Oregon  
Eugene OR 97403
- 1 DR. DIANE M. RAMSEY-KLEE  
R-K RESEARCH & SYSTEM DESIGN  
3947 RIDGEMONT DRIVE  
MALIBU, CA 90265
- 1 MINRAT M. L. RAUCH  
P II 4  
BUNDESMINISTERIUM DER VERTEIDIGUNG  
POSTFACH 1328  
D-53 BONN 1, GERMANY
- 1 Dr. Mark D. Reckase  
Educational Psychology Dept.  
University of Missouri-Columbia  
4 Hill Hall  
Columbia, MO 65211
- 1 Dr. Fred Reif  
SESAME  
c/o Physics Department  
University of California  
Berkeley, CA 94720

## Non Govt

- 1 Dr. Andrew M. Rose  
American Institutes for Research  
1055 Thomas Jefferson St. NW  
Washington, DC 20007
- 1 Dr. Ernst Z. Rothkopf  
Bell Laboratories  
600 Mountain Avenue  
Murray Hill, NJ 07974
- 1 DR. WALTER SCHNEIDER  
DEPT. OF PSYCHOLOGY  
UNIVERSITY OF ILLINOIS  
CHAMPAIGN, IL 61820
- 1 Dr. Alan Schoenfeld  
Department of Mathematics  
Hamilton College  
Clinton, NY 13323
- 1 Committee on Cognitive Research  
% Dr. Lonnie R. Sherrod  
Social Science Research Council  
605 Third Avenue  
New York, NY 10016
- 1 Dr. David Shucard  
Brain Sciences Labs  
National Jewish Hospital Research Center  
National Asthma Center  
Denver, CO 80206
- 1 Robert S. Siegler  
Associate Professor  
Carnegie-Mellon University  
Department of Psychology  
Schenley Park  
Pittsburgh, PA 15213
- 1 Dr. Edward E. Smith  
Bolt Beranek & Newman, Inc.  
50 Moulton Street  
Cambridge, MA 02138
- 1 Dr. Robert Smith  
Department of Computer Science  
Rutgers University  
New Brunswick, NJ 08903

Non Govt

- 1 Dr. Richard Snow  
School of Education  
Stanford University  
Stanford, CA 94305
- 1 Dr. Robert Sternberg  
Dept. of Psychology  
Yale University  
Box 11A, Yale Station  
New Haven, CT 06520
- 1 DR. ALBERT STEVENS  
BOLT BERANEK & NEWMAN, INC.  
50 MOULTON STREET  
CAMBRIDGE, MA 02138
- 1 Dr. Thomas G. Sticht  
Director, Basic Skills Division  
HUMRRO  
300 N. Washington Street  
Alexandria, VA 22314
- 1 David E. Stone, Ph.D.  
Hazeltime Corporation  
7680 Old Springhouse Road  
McLean, VA 22102
- 1 DR. PATRICK SUPPES  
INSTITUTE FOR MATHEMATICAL STUDIES IN  
THE SOCIAL SCIENCES  
STANFORD UNIVERSITY  
STANFORD, CA 94305
- 1 Dr. Kikumi Tatsuoka  
Computer Based Education Research  
Laboratory  
252 Engineering Research Laboratory  
University of Illinois  
Urbana, IL 61801
- 1 Dr. David Thissen  
Department of Psychology  
University of Kansas  
Lawrence, KS 66044

Non Govt

- 1 Dr. Douglas Towne  
Univ. of So. California  
Behavioral Technology Labs  
1845 S. Elena Ave.  
Redondo Beach, CA 90277
- 1 Dr. J. Uhlner  
Perceptrics, Inc.  
6271 Variel Avenue  
Woodland Hills, CA 91364
- 1 Dr. William R. Uttal  
University of Michigan  
Institute for Social Research  
Ann Arbor, MI 48106
- 1 Dr. Howard Wainer  
Division of Psychological Studies  
Educational Testing Service  
Princeton, NJ 08540
- 1 Dr. Phyllis Weaver  
Graduate School of Education  
Harvard University  
200 Larsen Hall, Appian Way  
Cambridge, MA 02138
- 1 Dr. David J. Weiss  
N660 Elliott Hall  
University of Minnesota  
75 E. River Road  
Minneapolis, MN 55455
- 1 Dr. Keith T. Wescourt  
Information Sciences Dept.  
The Rand Corporation  
1700 Main St.  
Santa Monica, CA 90406
- 1 DR. SUSAN E. WHITELY  
PSYCHOLOGY DEPARTMENT  
UNIVERSITY OF KANSAS  
LAWRENCE, KANSAS 66044
- 1 Dr. Christopher Wickens  
Department of Psychology  
University of Illinois  
Champaign, IL 61820
- 1 Dr. J. Arthur Woodward  
Department of Psychology  
University of California